

A management strategy evaluation of Pacific hake: implications of spatial distribution and differentiated harvest control rules.

Nis S. Jacobsen, Aaron M. Berger, Kristin N.
Marshall, Ian G. Taylor

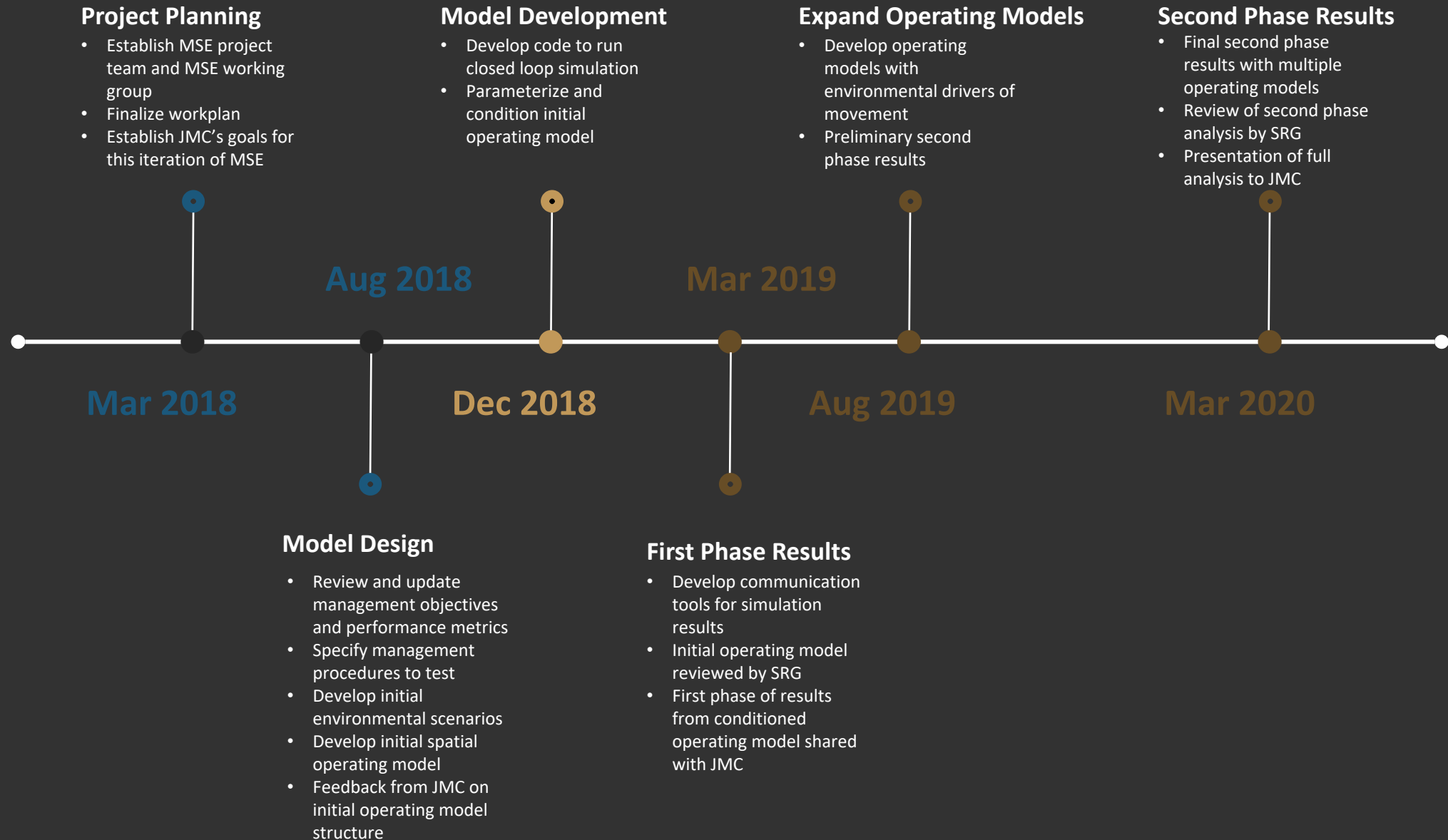
Disclaimer

Results show in this presentation are preliminary and should currently not be used for management decisions.

JMC's stated MSE goals

- Evaluate the performance of current hake management procedures under alternative hypotheses about current and future environmental conditions
- Better understand the effects of hake distribution and movement on both countries' ability to catch fish
- Better understand how fishing in each country affects the availability of fish to the other country in future years

Hake MSE Project Timeline



Management strategy evaluation (MSE)

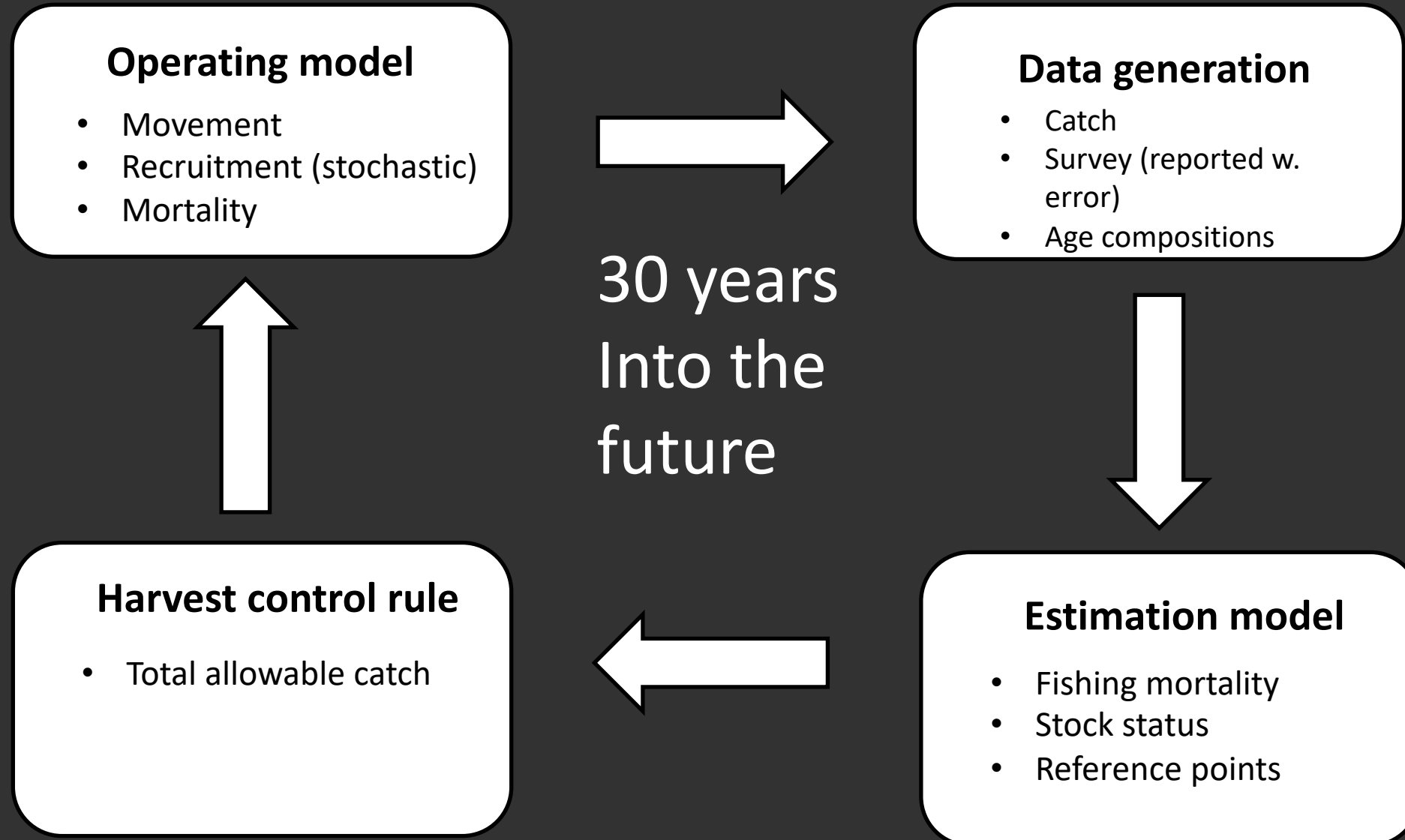
- Uses closed loop simulation to test management strategies
- Different strategies are tested in a future with uncertainty
- Is a collaborative effort with stakeholders and managers to reach pre-assigned goals and objectives for a fishery
- Can be used for hypotheses testing (e.g., changes in ecology, data collection scheme or assessment model)



Pacific hake MSE process

- Technical model written by NWFSC researchers
- Scenarios and objectives discussed with JMC and stakeholders (MSE working group)
- 'Hake MSE' working group has had three phone meetings discussing objectives and goals

Conceptual Pacific hake MSE simulation framework



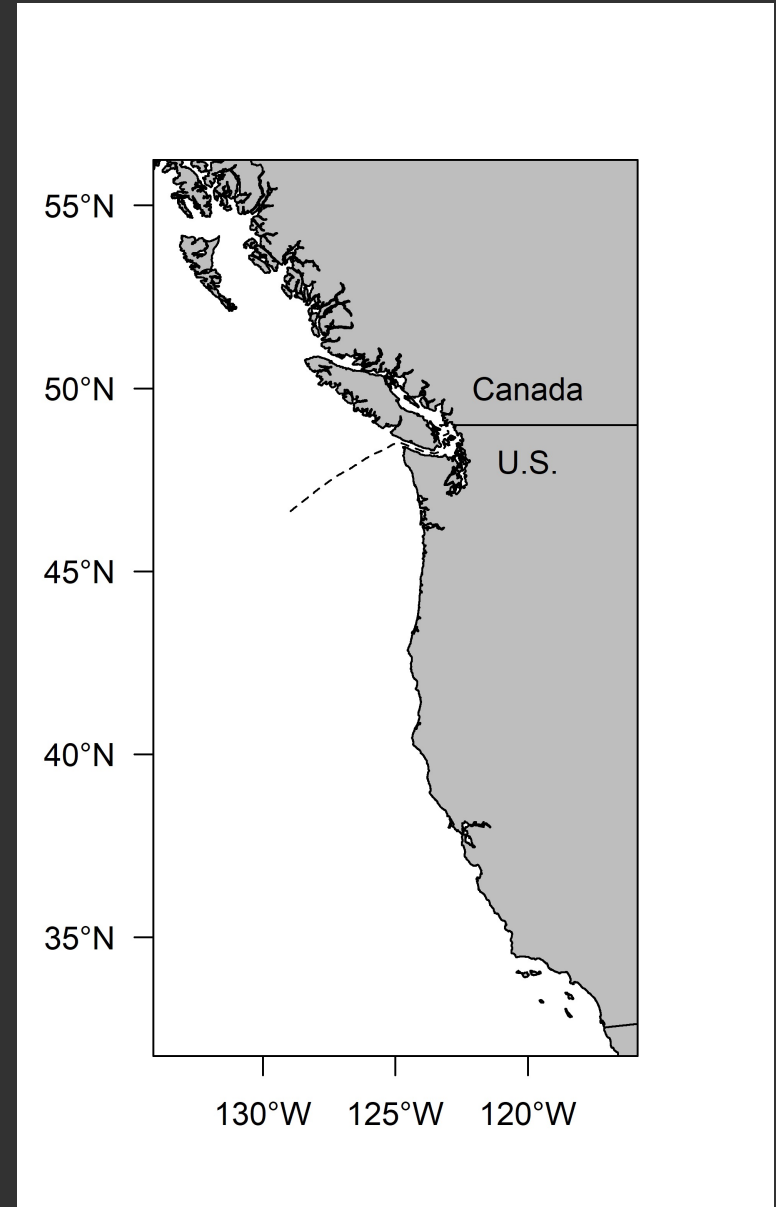
Estimation model

- Standard Stock Synthesis stock assessment model
- Rewritten in TMB for speed, R integration and increased transparency
- Faster than SS, and with possibility of adding random effects



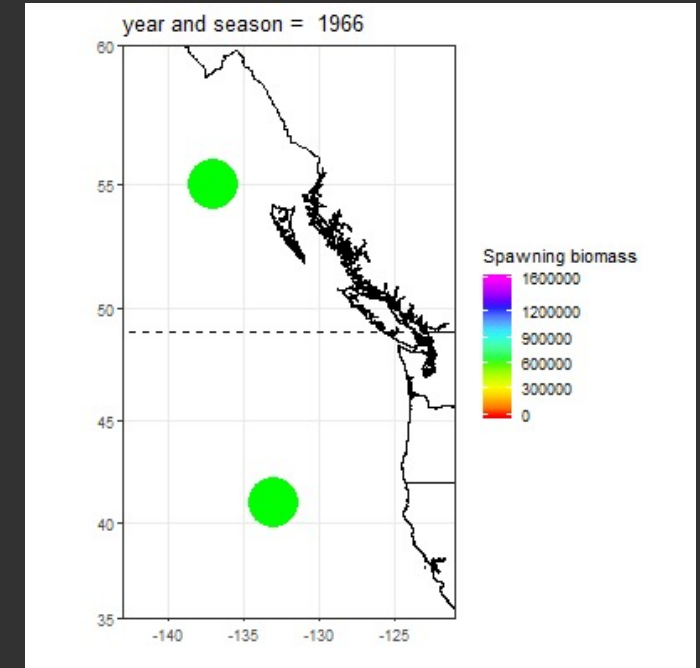
Operating model

- Age based model
- Time scale is four seasons per year
- Spatial: fish movement, fisheries, spawning, selectivity
- Movement happens in every season
- Produces data similar to the data available from the fishery
- Written in a flexible framework to allow exploration of different scenarios and OM configurations
- Conditioned upon available data from survey and fishery
- Written in R



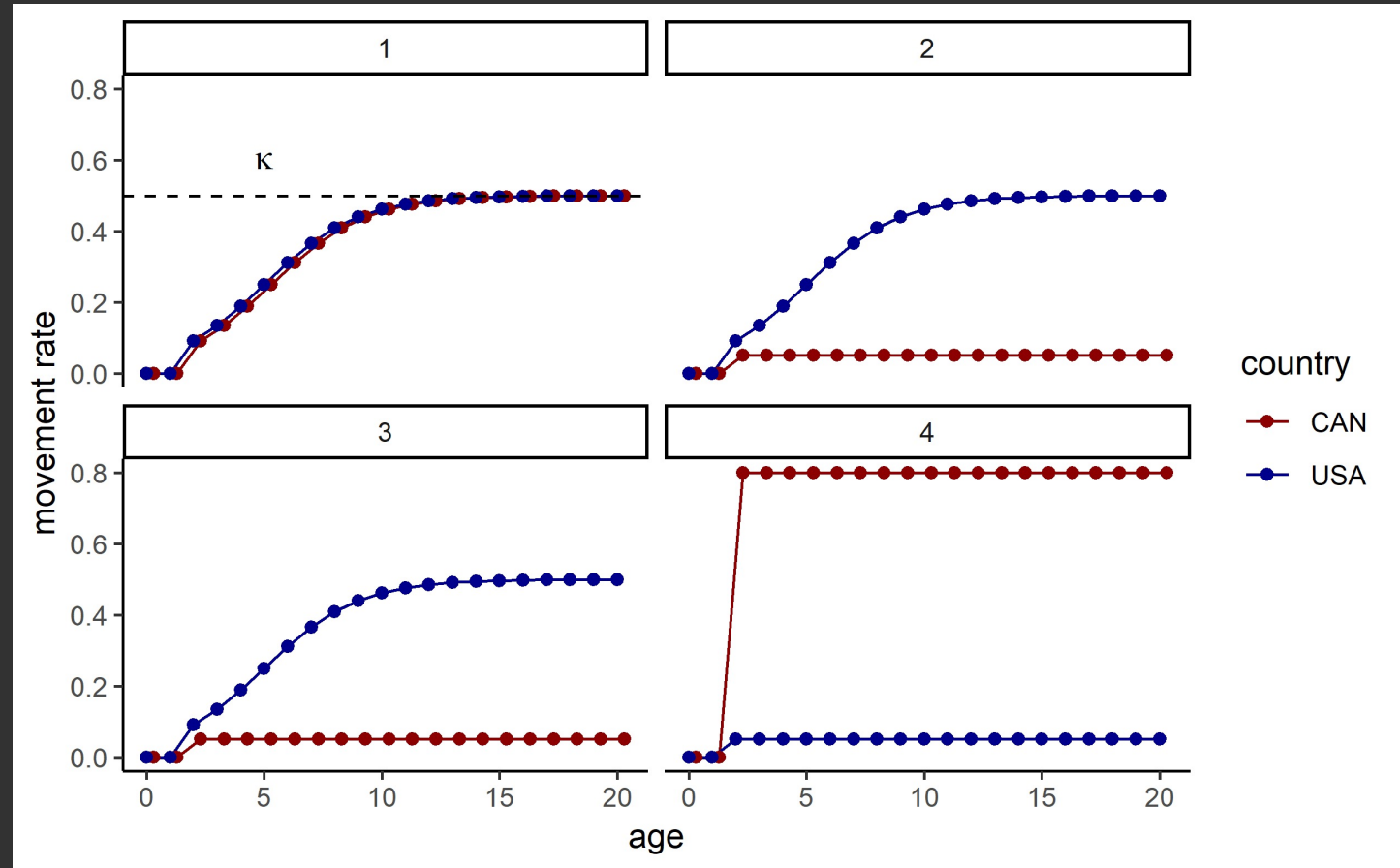
Movement

- Modeled as a fraction of the age group that moves out of an area
- Currently implemented as 2 boxes (they either move north or south) – the software is flexible
- Older individuals have a greater probability to move than smaller ones
- Most spawners move south in the last season of the year to spawn
- (The fish do not move south before spawning)



Seasonal movement parameters

$$\omega_a = \frac{\kappa_i}{1 + e^{-\gamma a - a_{50}}}$$



κ is the maximum movement rate

Spawning

- Beverton Holt with annual recruitment deviations
- Spawning occurs in the beginning of season one
- Stock recruitment relationship is area specific (depends on the spawners in each area) – deviations are the same for all areas
- Recruits (0-1 year) do not move



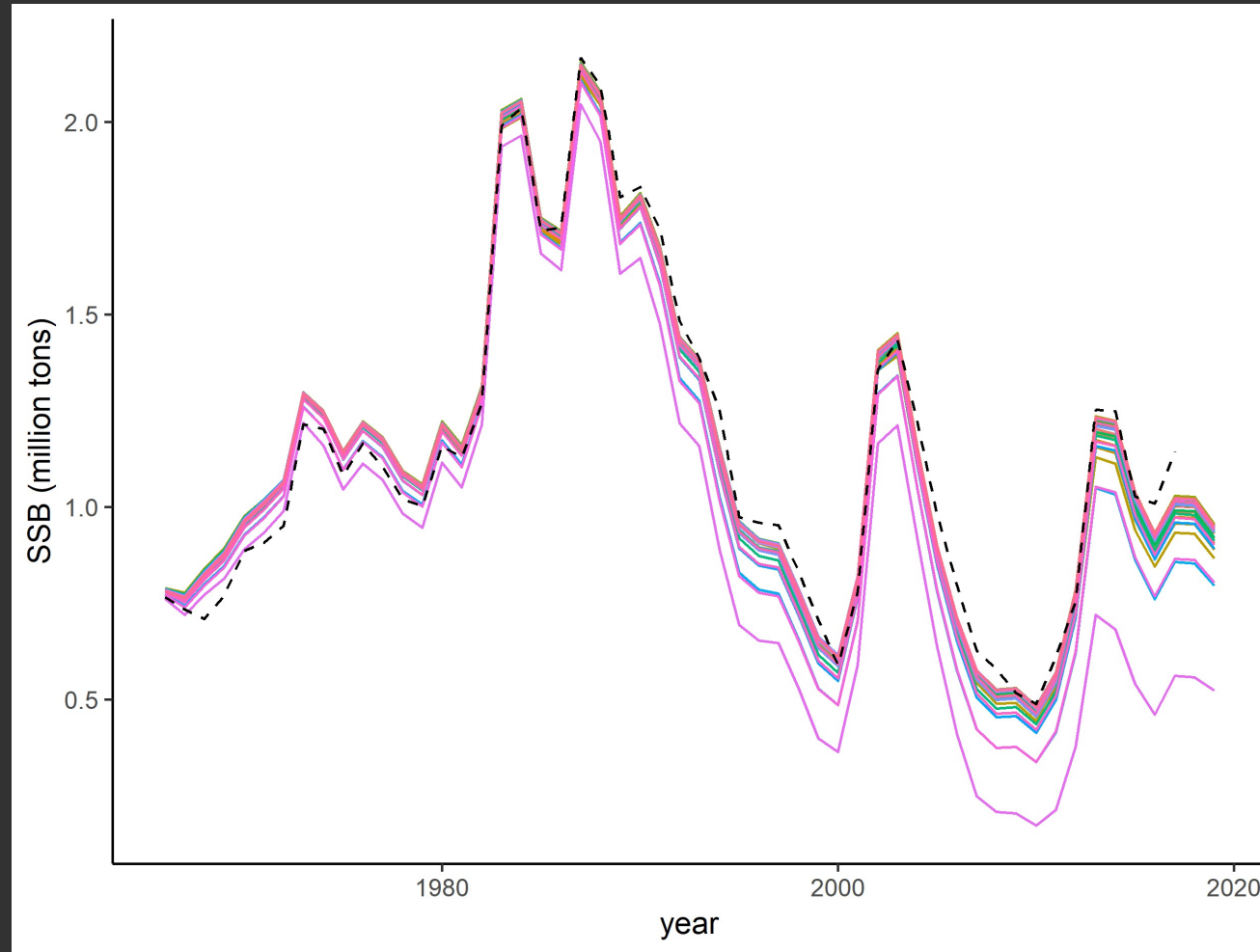
Photo credit Pete Frey (NWFSC)

Fisheries

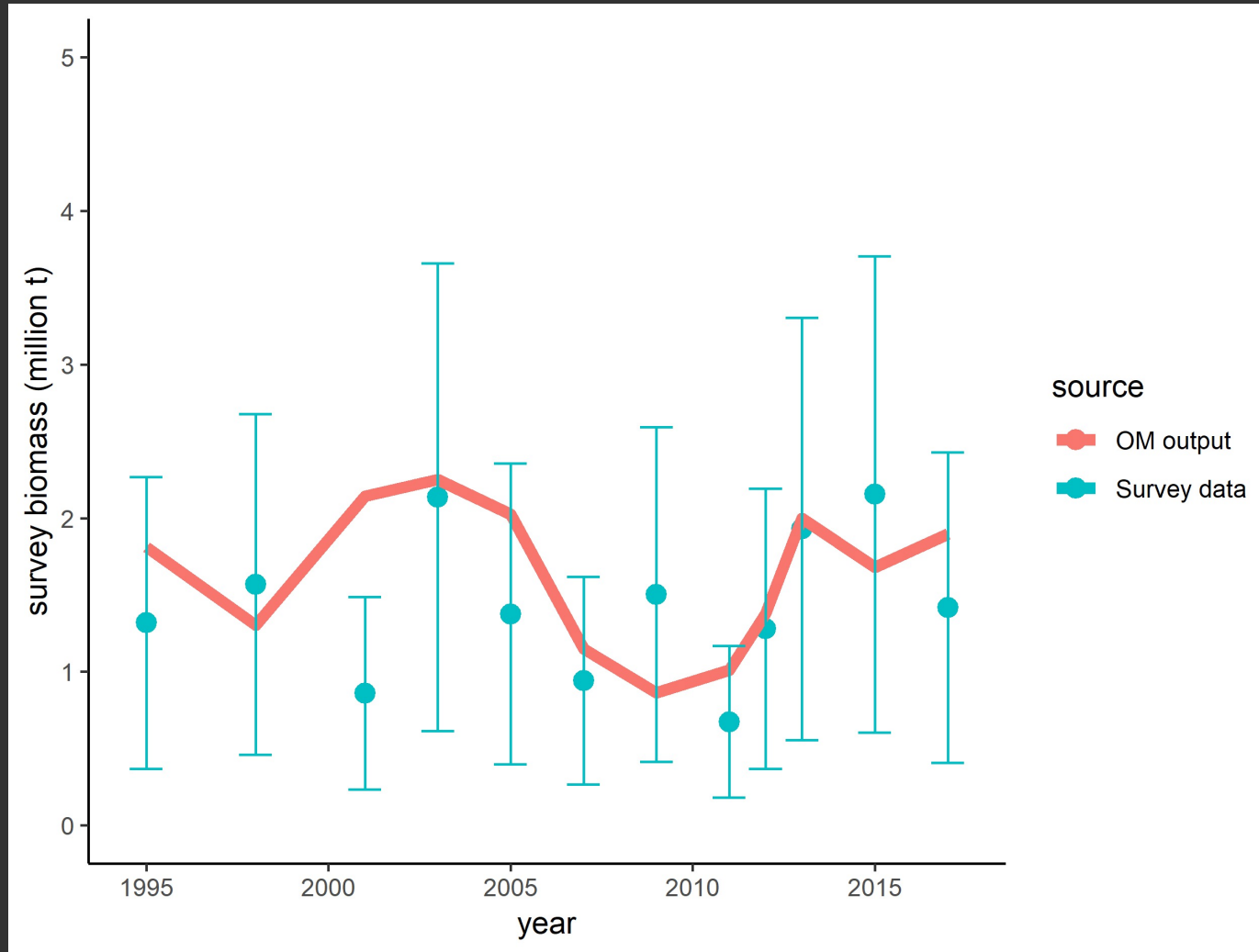
- Catch is divided by areas according to the Treaty
- The operating model calculates the fishing mortality in each area depending on the catch distribution per season
- Selectivity can be area specific or constant
- Catches occur predominantly in season 2 and 3



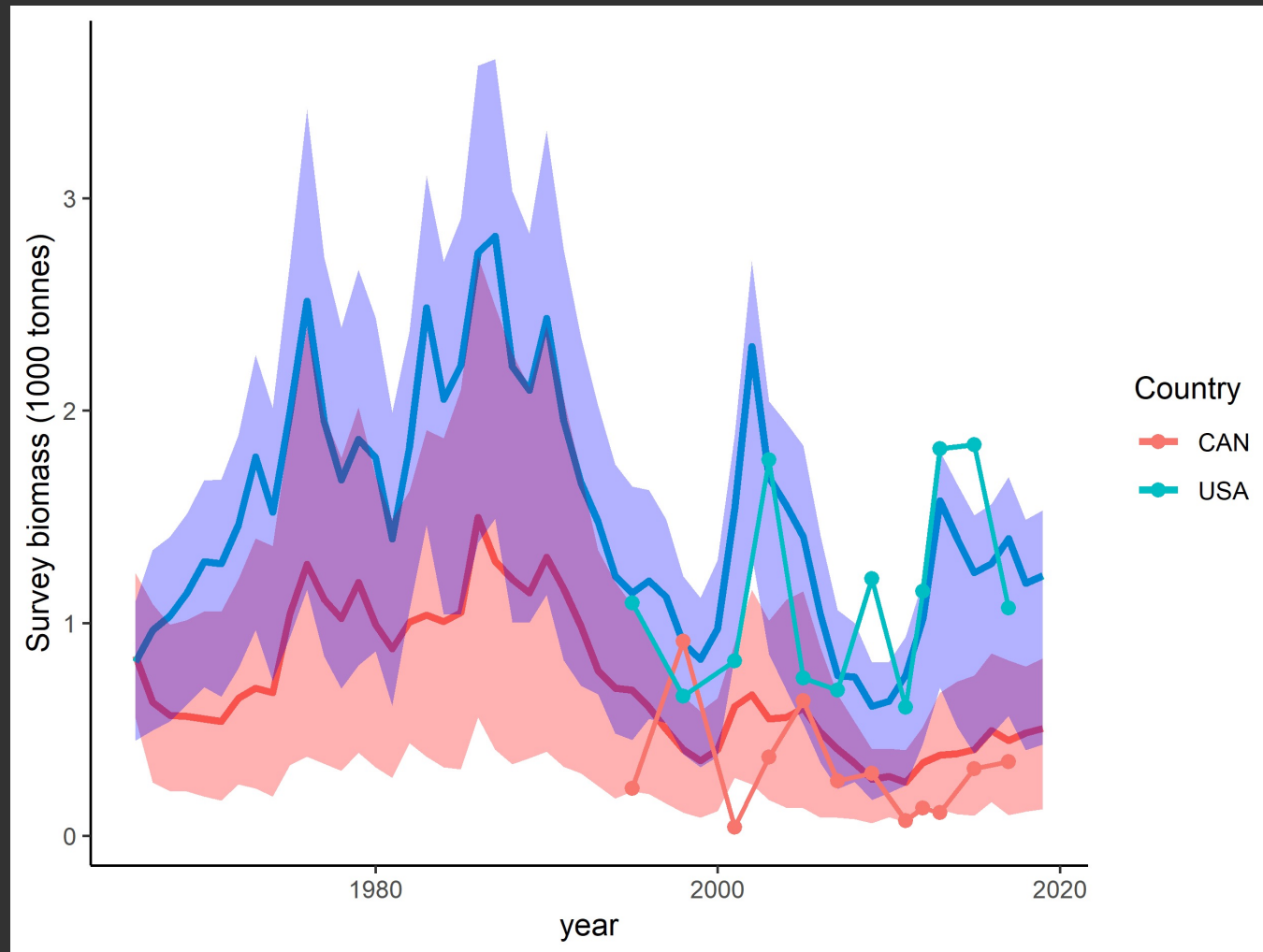
Total spawning biomass with varying movement parameters



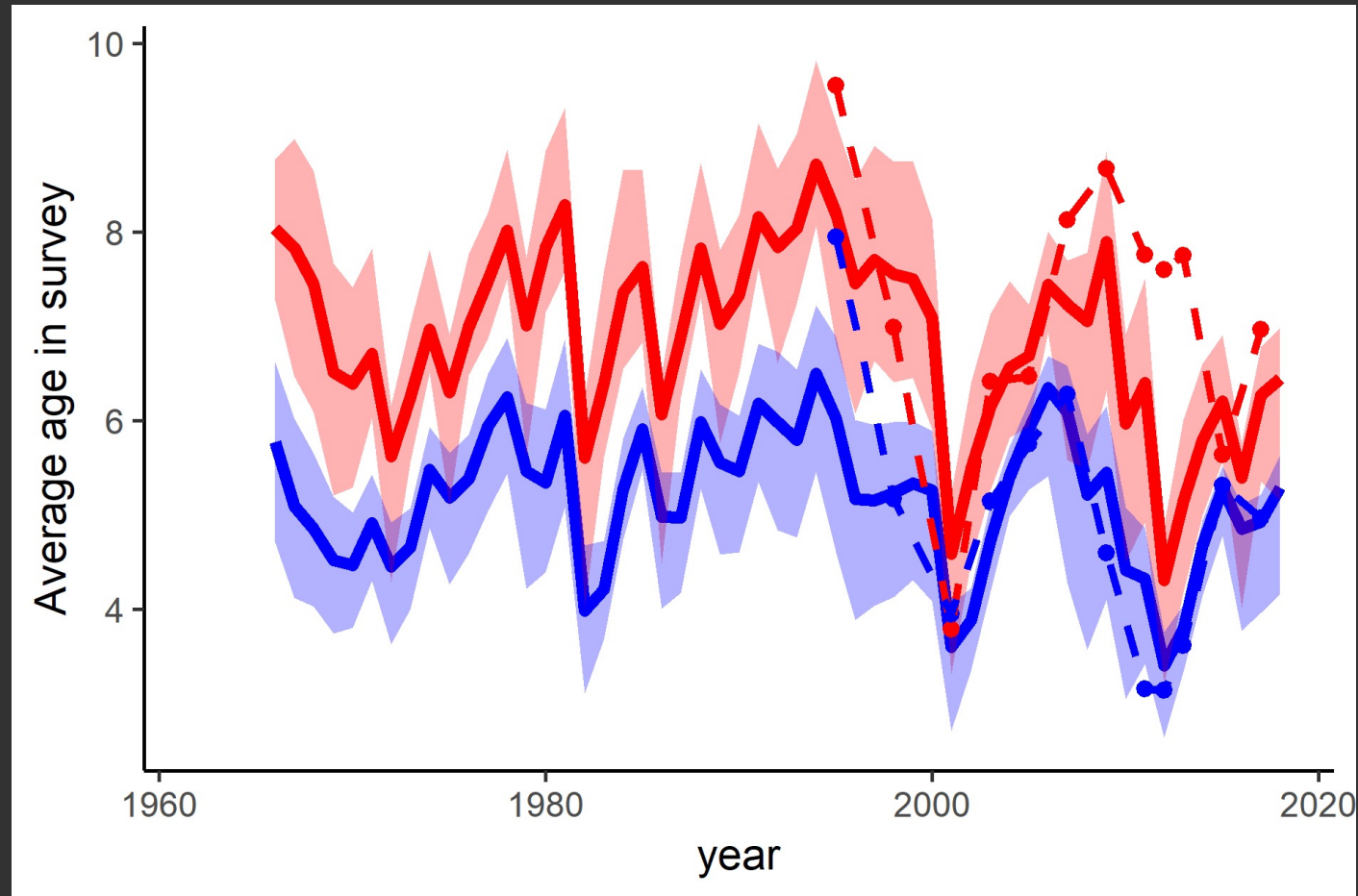
Biomass observed in survey



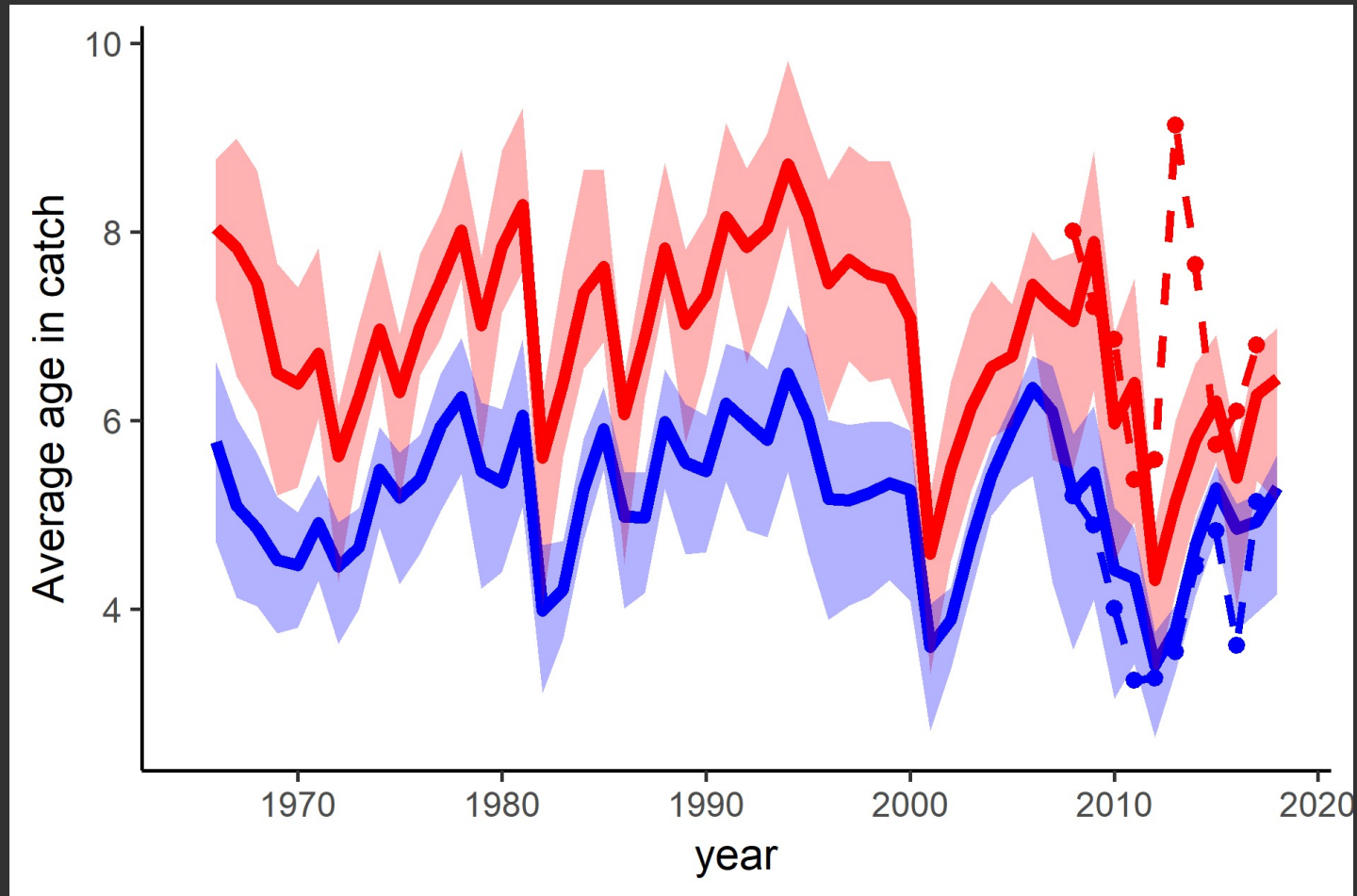
Survey biomass in Canada and USA



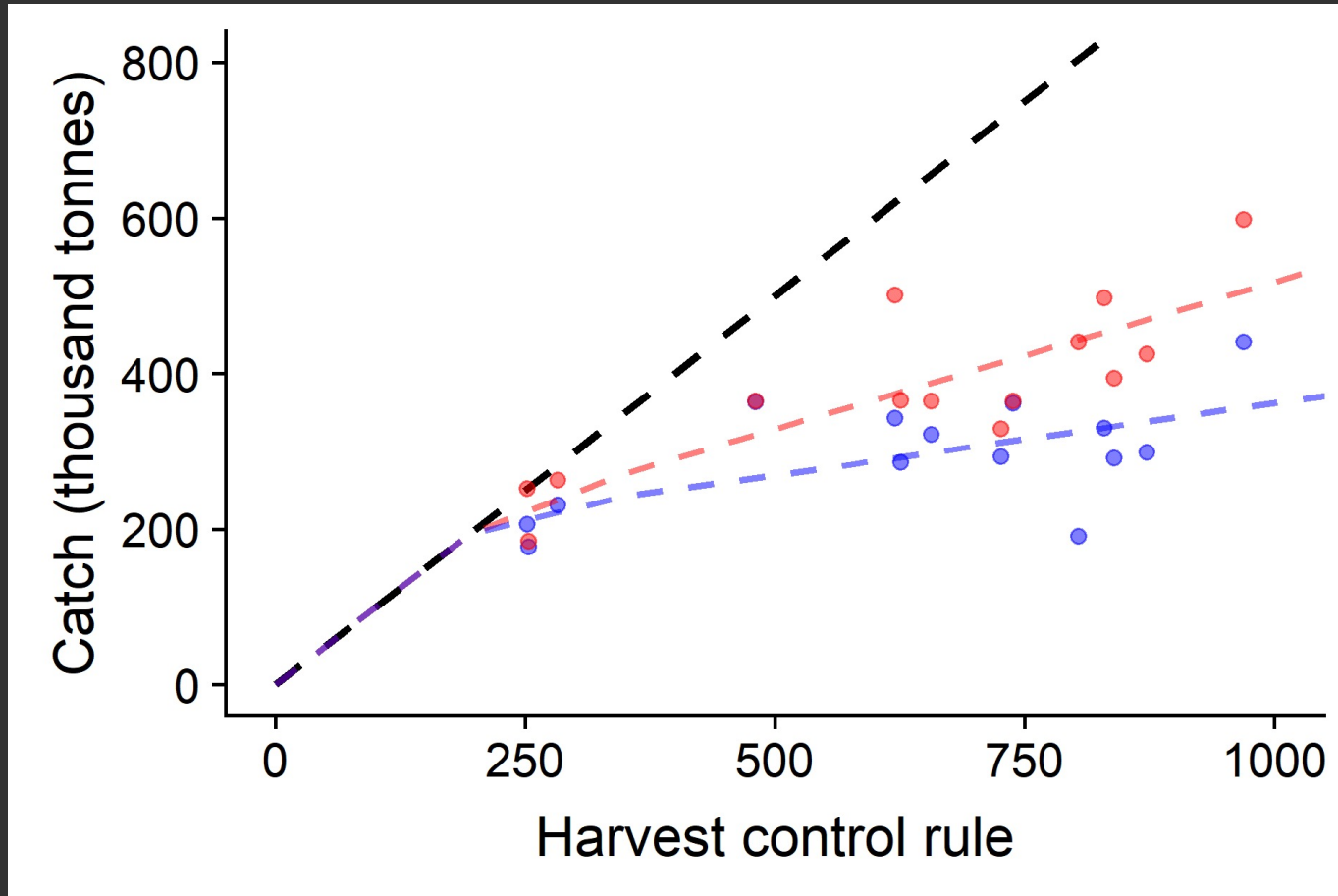
Average age in the survey



Average age in catch



Catch buffer by JMC and realized catch



- Standard HCR
- JMC catch buffer
- Realized catch buffer

Scenarios

- 6 different scenarios (first ones have a median movement rate)

1. Standard HCR
2. JMC catch buffer
3. Realized catch buffer

Movement scenarios (realized catch buffer)

1. Movement scenario 1 (low max movement rate)
2. Movement scenario 2 (high max movement rate)
3. Movement scenario 3 (low min. age to start movement)



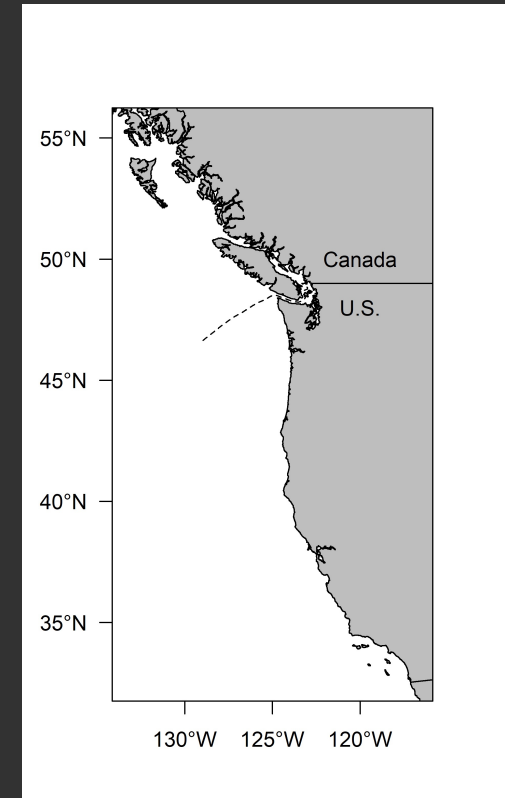
Management objectives identified by MSE working group

Coastwide objectives

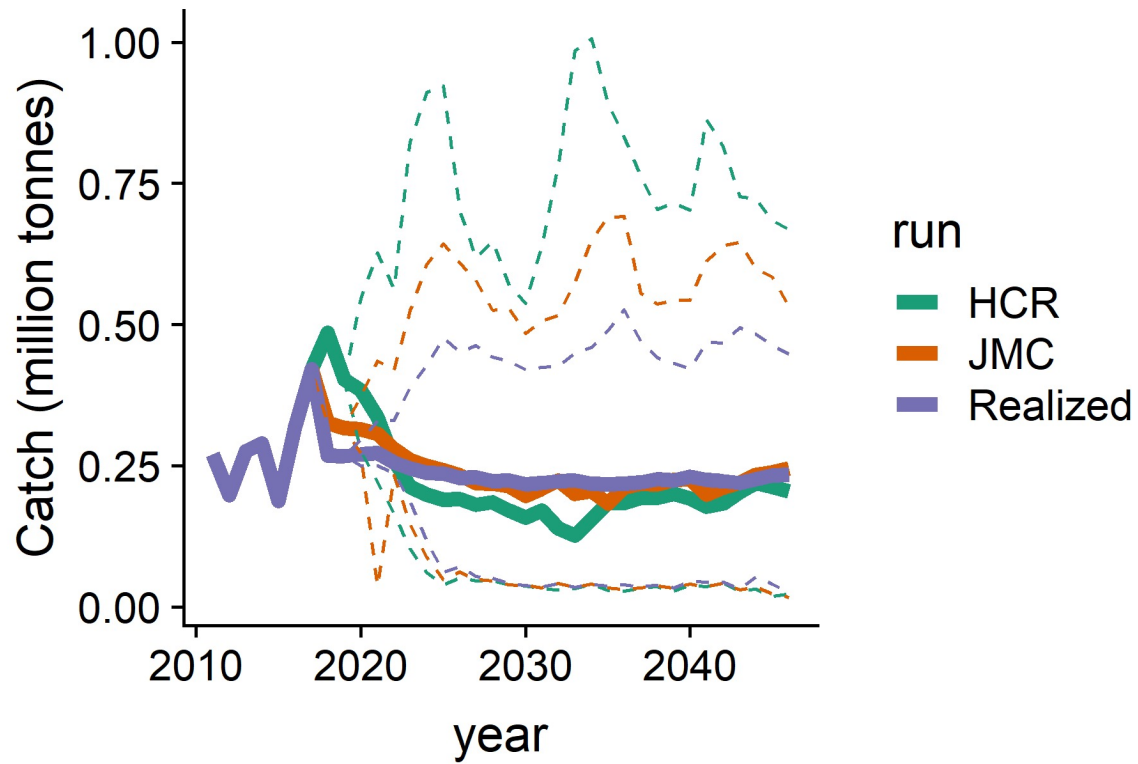
- Minimize risk of severe overfishing and closing the fishery
- Minimize the risk of the stock dropping below the specified management target for longer periods
- Avoid closing the fishery
- Avoid high variability in total catches
- Maintain high average coast wide catch

Spatial objectives

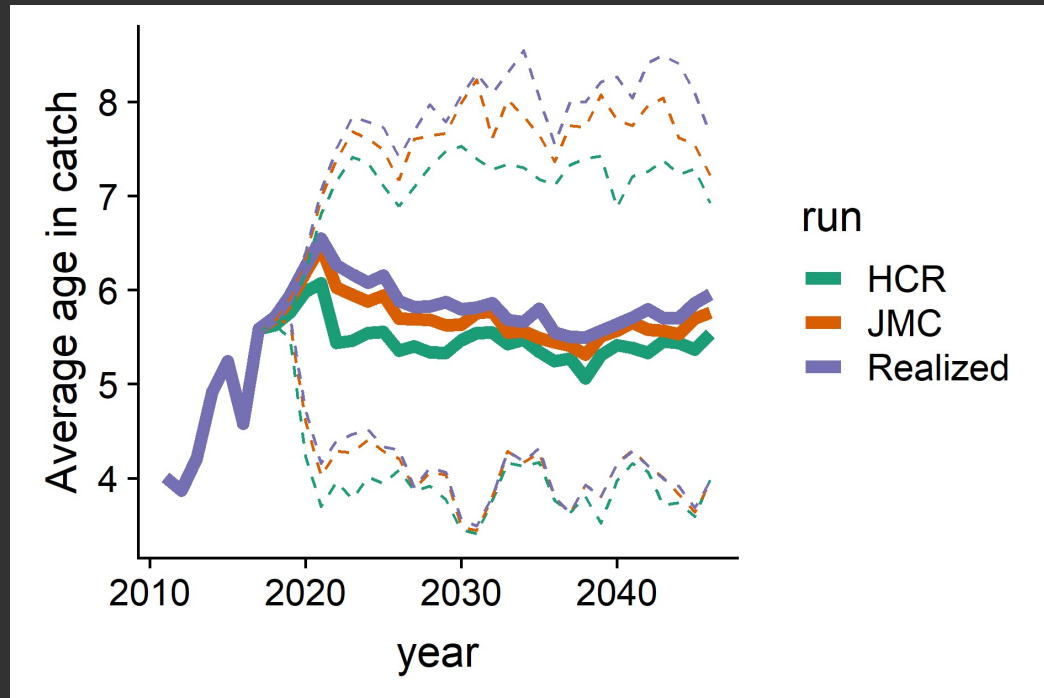
- Maintain enough biomass in both countries to maintain TAC allocation



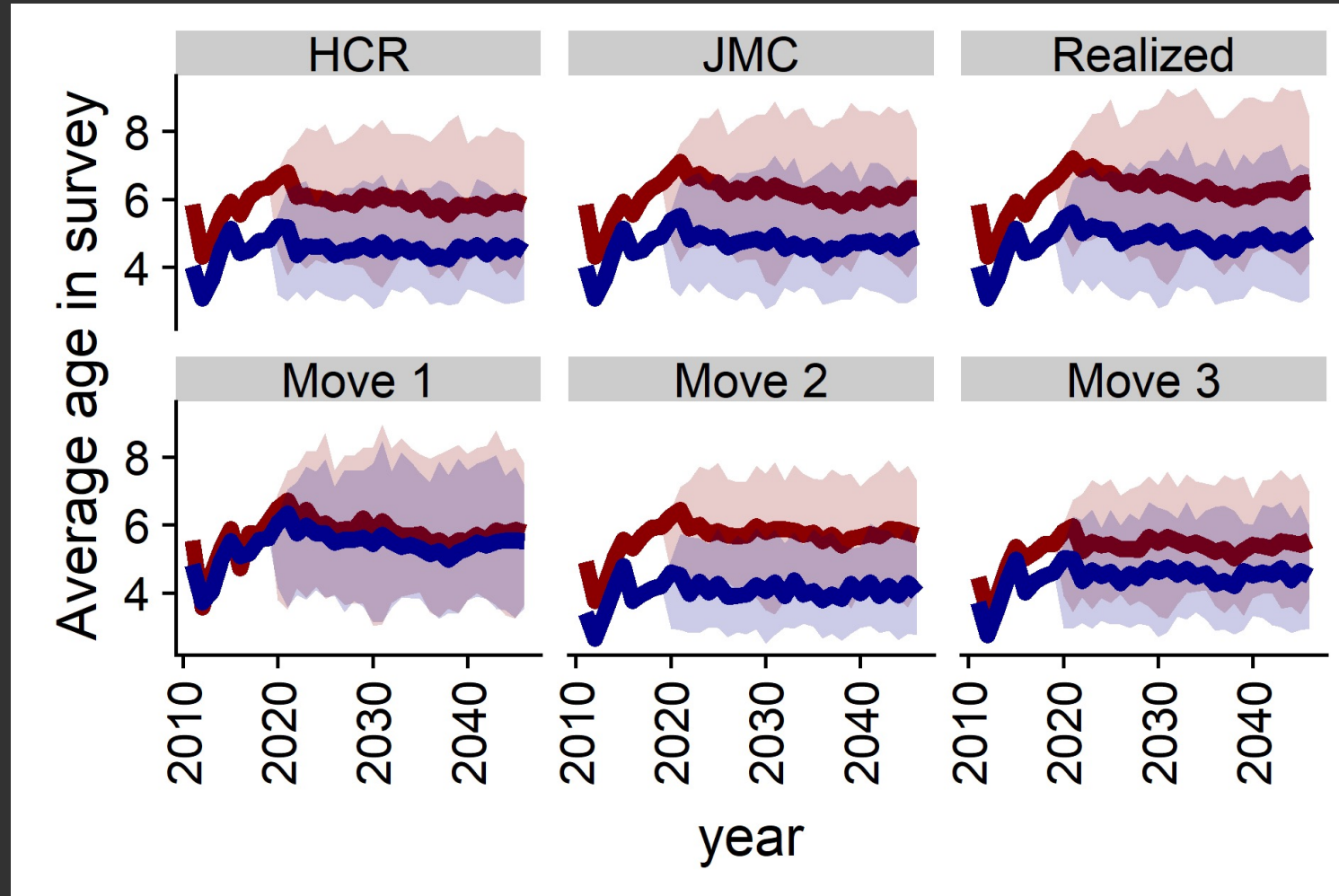
Total catches



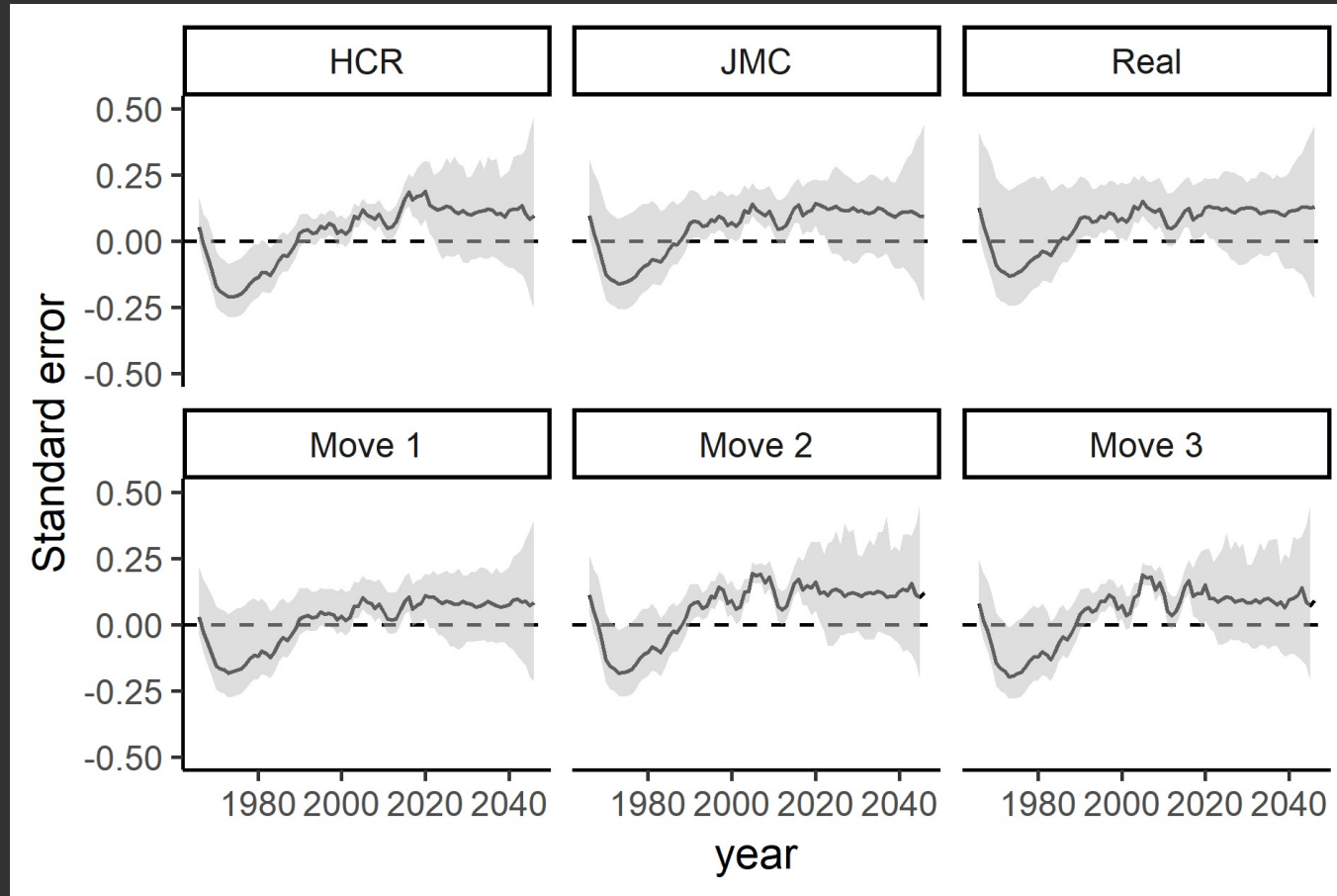
Age composition in the catch



Age composition between the countries

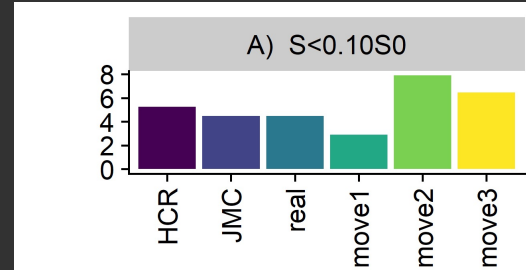


How well does the estimation model perform?



SE > 0 indicates the assessment model overestimates the actual SSB

Performance metrics



Move 1 = Low max movement

Move 2 = High max movement

Move 3 = Low age to start movement

Next steps

- Incorporate time-varying movement
- Investigate how movement influences selectivity estimation
- Test catch limits to achieve full TAC utilization for the two countries
- Time and spatially varying biological parameters

Conclusions

- The spatial structure has little impact on the management objectives (but some impact on assessment model)
- If movement changes in the future it might influence catches and stock status
- Recruitment deviations are the primary drivers of uncertainty



Thank you

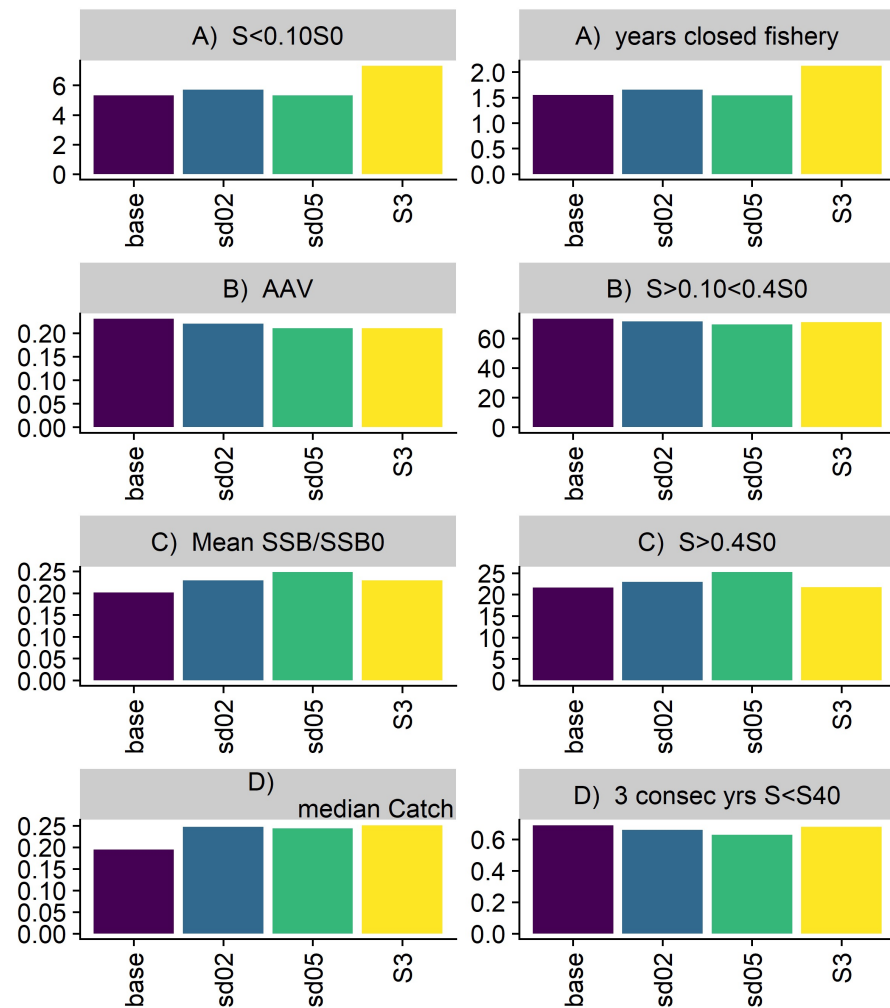


From Tuesday discussion

4 scenarios

- Base model (full utilization of HCR)
- Base model with year 1 survey (low variance, $sd = 0.2$)
- Base model with year 1 survey (medium variance, $sd = 0.5$)
- Base model with survey every 3 years, but year 1 with low variance ($sd = 0.1$)

Indicators



How do the models perform (ignore 2019 coding error)?

